(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 December 2001 (06.12.2001)

PCT

(10) International Publication Number
WO 01/91691 A1

(51) International Patent Classification[7]: A61G 11/00, A61B 5/08, G08B 23/00

(21) International Application Number: PCT/KR01/00767

(22) International Filing Date: 12 May 2001 (12.05.2001)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
2000/30129 1 June 2000 (01.06.2000) KR

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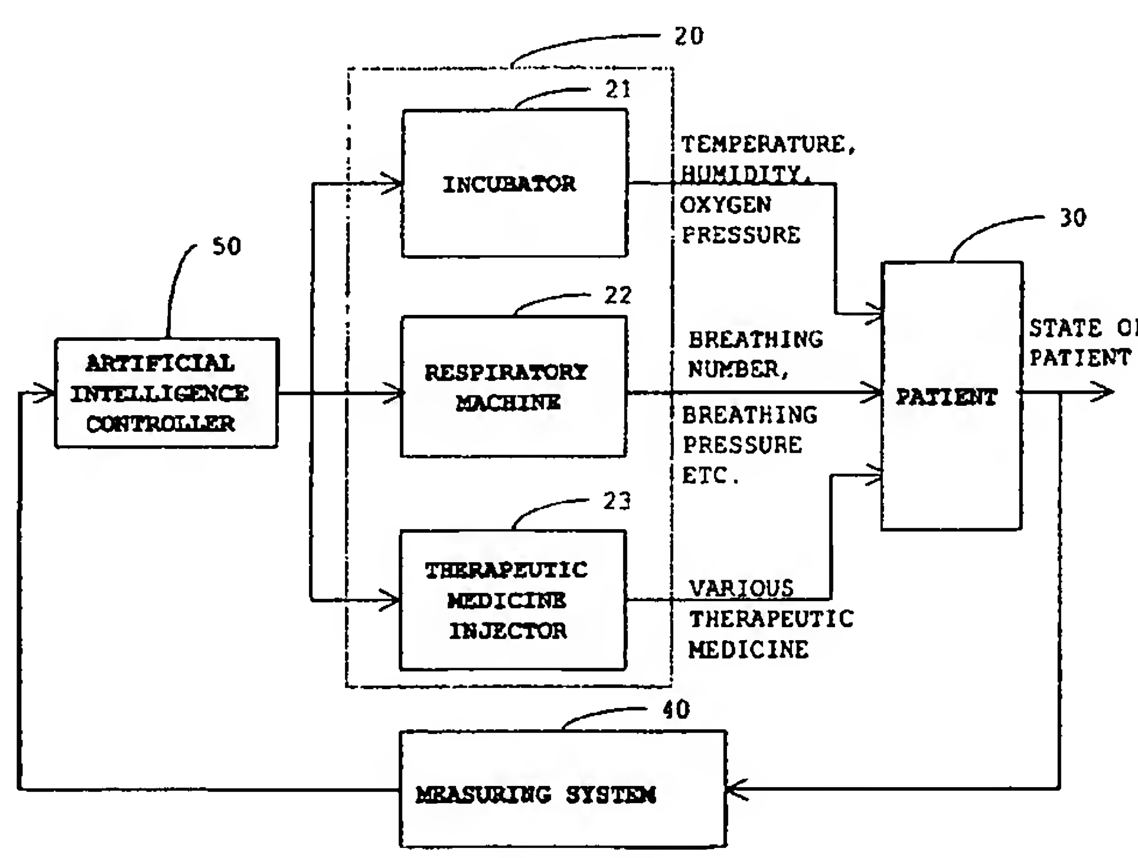
(81) Designated States (*national*): CN, JP, US.

(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ARTIFICIAL INTELLIGENCE INCUBATOR SYSTEM AND CONTROL METHOD THEREOF



(57) Abstract: In the intelligent type incubator system and a control method thereof, the system is constructed by various kinds of nurture/treatment equipments (20) which has an incubator (21), an artificial respiratory machine (22) and a therapeutic medicine injector (23), and which is provided for a nurture and/or a treatment of a patient; a measuring equipment for measuring and inputting various state data of the patient; and an artificial intelligence controller (50) for processing various kinds of state data of the patient (30) measured by the measuring equipment (40), as a control variable value for various setpoint values of the nurture/treatment equipment (20), on the basis of a neural network driven-type fuzzy inference model based on statistical information for a correlation between the state data of the patient (30) and an output of the nurture/treatment equipment (20) on the state data, and for controlling various outputs of the nurture/treatment equipment (20) on the basis of the processed control variable value.

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ARTIFICIAL INTELLIGENCE INCUBATOR SYSTEM AND CONTROL METHOD THEREOF

TECHNICAL FIELD

The present invention relates to an intelligent type incubator system and a control method thereof; and more particularly, to an intelligent type incubator system and a control method thereof, in which various kinds of information data concerning checked state of a patient are processed as control data of various kinds of treatment equipments for maintaining a normal state of a corresponding patient, and the outputs of the corresponding treatment equipments are automatically controlled, to thereby make a state monitoring of the patient and its diagnosis and treatment operation, closed-loop automatic controlled.

BACKGROUND ART

In general, an incubator system is provided as an important medical equipment having a function of temporarily nursing a patient under an abnormal state like an immature infant, and of recovering to a normal state of the patient through an appropriate treatment.

Fig. 1 is a block diagram of a conventional incubator system, and this

system is constructed by an incubator 12 for providing a proper environmental standard such as temperature, humidity and oxygen etc. within a closed space where there is a patient 11; an artificial respiratory machine 13 for controlling the breathing number and breathing pressure of the patient 11 etc. and artificially making the patient breathing; a therapeutic medicine injector 14 for injecting various therapeutic medicines to the patient 11; other equipments (not shown) for a treatment of the patient; and several kinds of measuring equipments 15 for measuring an electrocardiogram (ECG), blood pressure and the breathing number of the patient 11, etc.

In managing the conventional incubator system like Fig. 1, at the present hospitals, numerous manpower such as doctors, nurses and/or managing workers required is needed for all times of 24 hours, to monitor a physical change of state of the patient through several kinds of measuring equipments 15, re-determine an environment of the incubator 12 through a manual input equipment equipped with several kinds of treatment equipments such as the incubator 12, the respiratory machine 13 and the injector 14 etc. according to the monitoring result, or re-adjust a breath of the artificial respiratory machine(13) or an injection amount of the injector 14, or perform a monitoring for an error operation of an entire system

containing various kinds of measuring equipments 15.

However, in such conventional incubator system, a current state of the patient is recognized on the basis of measured values gotten by numerous measuring equipments, and a normal or abnormal state thereof is decided, and on the basis of doctor's own treatment experience and medical knowledge, reference inputs of various kinds of treatment equipments such as the incubator, the artificial respiratory machine and the injector etc. should be adjusted manually. Therefore, there are many problems for an economic waste caused by a commitment of much manpower and time, an inconvenience of a manual manipulation and a possibility for a diagnosis error which is caused by referring to a large number of state data for the sake of a decision of the doctor on a treatment method of the patient, etc.

DISCLOSURE OF THE INVENTION

Accordingly, the present invention is directed to an intelligent type incubator system and a control method thereof that substantially obviates one or more of the limitations and disadvantages of the related art.

A primary object of the present invention is to provide an intelligent type incubator system and a control method thereof, which is capable of making a state monitoring of a patient and its diagnosis and treatment

operation, closed-loop automatic controlled.

In accordance with the present invention for achieving the object, the intelligent type incubator system is constructed by a nurture/treatment equipment which includes an environment controlling part for controlling an air environment containing temperature, humidity and an oxygen amount within a given space according to a corresponding setpoint value, an artificially breathing part for artificially breathing of a lungs-breath life body according to the corresponding setpoint value, and an injection part for injecting various kinds of injection agents onto the life body according to the corresponding setpoint value; a measuring unit for measuring a state of the life body like a medical and biological metabolism etc., the life body being as the object body under a nurture and/or a treatment through the nurture/treatment equipment; and an artificial intelligence controlling unit for processing state data of the life body measured by the measuring unit, as a control variable value for various setpoint values of the nurture/treatment equipment, on the basis of a neural network driven-type fuzzy inference model based on statistical information for a correlation between a state of the life body and an output of the nurture/treatment equipment, and for controlling the output of the nurture/treatment equipment on the basis of the processed control variable value.

In order to achieve the above objects in accordance with the present invention, in a controlling method of the intelligent type incubator system having the nurture/treatment equipment and manually varying a setpoint value of the nurture/treatment equipment according to a state of a corresponding life body, the nurture/treatment equipment containing an incubator for controlling an air environment containing temperature, humidity and an oxygen amount within a given space according to the setpoint value, an artificial respiratory machine for artificially breathing of a lungs-breath life body according to the setpoint value, and an injecting apparatus for injecting various kinds of injection agents onto the life body according to the setpoint value; the method includes the steps of: constructing a plural number of fuzzy inference rules on the basis of a statistical distribution of the setpoint value of the nurture/treatment equipment on the state data of the life body, and forming the plural number of fuzzy inference rules as the structure of the neural network; dividing the state data of the life body and its based setpoint value of the nurture/treatment equipment into a plurality of groups corresponding to the plural number of fuzzy inference rules and establishing them, on the basis of expert information on the nurture and/or treatment of the life body, and forming the respective established groups as the neural network structure;

individually dividing various kinds of state data of the life body for the learning into groups based on the number of the inference rules; deciding a coupling coefficient of the neural network of the respective groups through a repeated learning based on the neural network driven type fuzzy inference rules and the divided data, and also deciding a coupling coefficient of the neural network of the respective group through repeated learning based on the neural network structure of the respective group and the divided data; deciding a membership value of the state data measured and inputted from the corresponding life body on the basis of the learned neural network driven-type fuzzy inference model; deciding an estimation value of a corresponding setpoint value of the nurture/treatment equipment for the state data measured and inputted, on the basis of the learned neural network model of the respective group; and calculating and getting the corresponding setpoint value of the nurture/treatment equipment on the basis of the decided membership value and estimation value, and controlling an output of a corresponding nurture/treatment equipment on the basis of the calculated setpoint value.

In this present invention, a treatment experience of a corresponding expert doctor and a special knowledge for the life body, on the basis of a recognition for a state of the life body, are established as a

knowledge-based system of an artificial intelligence so that system itself has a judgment function, thereby, a corresponding nurture/treatment equipment is appropriately controlied so as to lead the life body to be normally nurtured, treated and restored to health.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

Fig. 1 is a block diagram of a conventional incubator system;

Fig. 2 indicates a block diagram of an intelligent type incubator system in one embodiment of the present invention;

Fig. 3 depicts a constructive diagram for an algorithm of a neural network driven-type fuzzy inference model of an artificial intelligence controller shown in Fig. 2;

Fig. 4 is a drawing showing, on a two dimensional plane, group data classified under an assumption that there are two inputs to embody a neural

network driven-type fuzzy inference model of an artificial intelligence controller shown in Fig. 2; and

Fig. 5 sets forth a drawing showing another constructive example for embodying a inference rule of an artificial intelligence controller shown in Fig. 2.

BEST MODE FOR CARRYING OUT THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

In accordance with the present invention, an intelligent type incubator system and a controlling method thereof are described in detail, as follows.

Fig. 2 is a block diagram of an intelligent type incubator system in one embodiment of the present invention, and the intelligent type incubator system includes a nurture/treatment equipment 20 which has an incubator 21 for outputting temperature of air, humidity, oxygen, pressure, and air controlled by each setpoint value for an air flowing quantity, and controlling a quality of air supplied into the inside of a given space, an artificial respiratory machine 22 for outputting oxygen controlled according to each

setpoint value for expiration/inspiration pressure, oxygen content, the breathing number per unit time, humidity and temperature, and for artificially breathing of the lungs breathing life body (hereinafter, referred to as "patient") 30, a therapeutic medicine injector 23 for controlling and outputting an actual injection amount according to a setpoint value concerning the injection amount and for injecting various kinds of a therapeutic medicine to the patient 30; a measuring equipment 40 for measuring and inputting various kinds of state data which contains an electrocardiogram (ECG) having irregular pulse and the pulse number representing a state of a medical and biological metabolism etc. of the patient 30, and also contains the breathing number, an oxygen saturation degree, percutaneous oxygen partial pressure, percutaneous dioxide partial pressure, body temperature, weight and ages; and an artificial intelligence controller 50 for processing various kinds of state data of the patient 30 measured by the measuring equipment 40, as a control variable value for various setpoint values of the nurture/treatment equipment 20, on the basis of a neural network driven-type fuzzy inference model based on statistical information for a correlation between the state data of the patient 30 and an output of the nurture/treatment equipment 20 on the state data, and for controlling various outputs of the nurture/treatment equipment 20 on the

basis of the processed control variable value.

Referring to Fig. 2, in the present invention it is formed a closed-loop system constructed by the nurture/treatment equipment 20, the patient 30, the measuring equipment 40 and the artificial intelligence controller 50. The artificial intelligence controller 50 receives in feedback a state of the patient 30 through the measuring equipment 40, and processes and outputs the inputted state data of the patient, as the control variable value for various setpoint values, on the basis of the neural network driven-type fuzzy inference model, and sends out it as an input signal of the nurture/treatment equipment 20 containing the incubator 21, the artificial respiratory machine 22 and/or the injector 23, to thereby control the control object like the patient 30 through various kinds of nurture/treatment equipments 20.

In an aspect of a dynamic viewpoint, the artificial controller 50 performs a function of recovering the patient to a stabilized balance state, namely, a normal state, through an appropriate procedure, on the basis of knowledge for a current state and a peculiarity of the patient 30, namely, treatment experience of a doctor and medical knowledge for the human body etc.

It is described contents for the input/output signals constructing the inventive system, as follows.

An input of the incubator 21 become a setpoint values for humidity, oxygen partial pressure and temperature of air supplied to the incubator 21 inside, and an air flowing amount, and an output thereof becomes the air controlled by the setpointed value. An input of the artificial respiratory machine 22 becomes a setpoint value for expiration/inspiration pressure, an oxygen content, the breathing number per unit time, humidity and temperature, and an output thereof becomes the oxygen controlled by the setpoint value. An input of the therapeutic medicine injector 23 becomes a setpoint value for the amount of the therapeutic medicine injection, and an output thereof becomes an actual injection amount based on the setpoint value. An input of the patient 30 becomes various kinds of outputs of the nurture/treatment equipment 20 which contains the incubator 21, the respiratory machine 22 and the injector 23, and an output thereof becomes, a state of the patient, the electrocardiogram (ECG) having the irregular pulse and the pulse number, blood pressure, the breathing number, the oxygen saturation degree, the percutaneous oxygen partial pressure, the percutaneous dioxide partial pressure, the body temperature, the weight and age, etc.

The artificial intelligence controller 50 gains information for value of the above-mentioned input/output signal, and processes the current state

data of the patient 30 measured by the measuring equipment 40, as the control variable value for various setpoint values of the nurture/treatment equipment 20, on the basis of the neural network driven-type fuzzy inference model established by the expert knowledge and statistical information for the correlation between various state data of the patient 30 and a selective output of the nurture/treatment equipment 20, and also, controls various outputs of the nurture/treatment equipment 20 on the basis of the processed control variable value. The establishment of the neural network driven-type fuzzy inference model and its inventive control method are described in detail, as follows.

Fig. 3 is a constructive diagram for an algorithm of the neural network driven-type fuzzy inference model of the artificial intelligence controller 50 shown in Fig. 2. Describing first a decision method of the membership value, the fuzzy inference model constructs a fuzzy inference rule by using the expert knowledge of a doctor and the statistic distribution of the setpoint value of the nurture/treatment equipment 20 for various kinds of state data of a patient, and the state data of the patient for a learning is divided into groups by the number of rules, and it is decided a coupling coefficient of units in each hierarchy of the neural network NNm through the learning. From such learned neural network model, the membership value

(μF1, μF2, . . . , μFr) of actual state data (xi1, xi2, ... , xin) is decided.

Next, describing a decision for an output value of the artificial intelligence controller 50, the state data of the patient for the learning, and its based output value, namely, the setpoint value of the nurture/treatment equipment 20, are classified according to the rule, and the coupling coefficient of the neural network is decided. An estimated output value (y_{ei}^1, y_{ei}^2, . . . , y_{ei}^r) for an actual state input (x_{i1}, x_{i2}, ... , x_{in}) is obtained from the learned neural network model (NN_1~NN_r), and is combined with the previously obtained membership value (μF_1, μF_2, . . . , μF_r), thus a setpoint value (y_i^*) of the nurture/treatment equipment 20 to control the state of the patient 30 is gained.

A driving algorithm of the neural network driven-type fuzzy inference model of such artificial intelligence controller 50 is described in detail step by step, as follows.

In a first step, an input variable value concerning an output y_i is decided. For example, if the blood pressure, the breathing number and the body temperature of the patient becomes close to temperature within the incubator, an input variable x_i of the controller 50 becomes the blood pressure, the breathing number and the body temperature measured and fed back from the patient, and an output of the controller 50 becomes setpoint

temperature of the incubator 21. Representing in symbols, it becomes the input variable $x_i^T = (x_{i1}, x_{i2}, x_{i3})$, and x_{i1} represents the blood pressure, x_{i2} indicates the breathing number, x_{i3} as the human body temperature, y_i as the setpoint temperature, and i represents a time sequence.

In a second step, the input/output data for the variable value decided like the first step is divided into groups of the r number based on the number of inferences as shown in Fig. 4, and each group is represented as $G_j(j = 1, 2, \ldots, r)$. For instances, data ensured from the treatment experience and medical knowledge of a doctor is classified into groups of the r number according to a statistical distribution of an output. Assuming that there are two inputs for convenience, the classified group data can be represented on the two-dimensional plane as shown in Fig. 4.

In a third step, the coupling coefficient of a network is decided from a neural network structure NN_m of a membership function of Fig. 3 and the data divided into the groups of the r number through repeated learning. For instances, in case that the input data x_i belongs to a group G_2, an output of NN_m becomes $(0, 1, 0, 0, \ldots, 0)$.

In a fourth step, the coupling coefficient of the network is decided through the repeated learning from a neural network structure NN_1. $NN_2, \ldots, NN_r$ of Fig. 3 and a divided data group, namely, (x_i^j, y_i^j). For

example, if the input data is the data belonging to the G_2 group, the coupling coefficient is decided through an application to the NN_2 structure.

In a final fifth step, data measured in real time and extracted, namely, the state data of the patient, will be generally distributed randomly within a given range. At this time, an output value of the controller 50 is decided from the inference network structure decided in the fourth step on the following numerical expression 1.

$$y_i = \frac{\sum_{j=1}^{r} \mu F_j(x_i) \times y_{ei}^{j}}{\sum_{j=1}^{r} \mu F_j(x_i)} \qquad \cdots\cdots\cdot (1)$$

For example, when an output of the membership function NN_m is "$\mu F_j(x_i) = (0.5, 0.2, 0.2)$, $j=1,2,3$", and an output of NN_j is "$y^j_{ei} = (3, 1, 0.5)$", it becomes "$y_i^* = 0.8/0.9 = 2$", and a final output value is gained by applying a proper scaling factor determined in a data manipulation, and this value is provided as the output of the controller 50.

Fig. 5 presents another constructive example for realizing a inference rule of the artificial intelligence controller shown in Fig. 2, and herewith, an output y^* is obtained as follows.

In a first step, a fuzzy inference rule is decided by the r number, from the statistical distribution of the input/output data. For instances, R^i : IF x_1 is

$A_{i1.1}$, and x_2 is $A_{i2.2}$ THEN $y = \omega_i(x_1, x_2)$. Herewith, it is assumed that the input variable is two of x_1 and x_2, and $i = 1, 2, \ldots, r$ (the number of inference rules), and $A_{i1.1}$ and $A_{i2.2}$ represent a membership function of the input variables x_1, x_2, and i_1, i_2 indicates a sort of a membership function for the respective input variables x_1 and x_2, and ω_i is an inference value corresponding to each inference rule decided by the learning.

$$\mu_i = A_{i1.1}(x_1)\, A_{i2.2}(x_2)$$

$$\hat{\mu} = \frac{\mu_i}{\sum_{k=1}^{r} \mu_k} \quad \cdots\cdots (2)$$

In a final third step, an inference value y^* of an output is decided on the basis of the following numerical expression 3.

$$y^* = \sum_{i=1}^{r} \hat{\mu}_i \omega_i \quad \cdots\cdots (3)$$

INDUSTRIAL APPLICABILITY

As afore-mentioned, in the inventive intelligent type incubator system and a control method thereof, the existing open loop incubator system adjusted manually and operated by a setpoint value is constructed as a closed-loop system by realizing an artificial intelligence controller based

on a neural network driven-type fuzzy inference model, to whereby control a state of a patient automatically and recover to a normal state. Accordingly, according to an establishment of the inventive closed-loop automatic control system, there are advantages of remarkably lessening an economic waste caused by numerous manpower commitment to the existing incubator system and reducing an error in a diagnosis and treatment to be caused by a frequent monitoring on a state of the patient.

It will be apparent to those skilled in the art that various controls and variations can be made in the present invention without deviating from the spirit or scope of the invention. Thus, it is intended that the present invention cover the controls and variations of this invention provided they come within the scope of the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. An intelligent type incubator system comprising:

a nurture/treatment equipment which includes an environment controlling part for controlling an air environment containing temperature, humidity and an oxygen amount within a given space according to a corresponding setpoint value, an artificially breathing part for artificially breathing of a lungs-breath life body according to the corresponding setpoint value, and an injection part for injecting various kinds of injection agents onto the life body according to the corresponding setpoint value;

a measuring unit for measuring a state of the life body as the object body under a nurture and/or a treatment through the nurture/treatment equipment; and

an artificial intelligence controlling unit for processing state data of the life body measured by the measuring unit, as a control variable value for various setpoint values of the nurture/treatment equipment, on the basis of a neural network driven-type fuzzy inference model based on statistical information for a correlation between a state of the life body and an output of the nurture/treatment equipment, and for controlling an output of the nurture/treatment equipment on the basis of the processed control variable

value.

2. A controlling method of an intelligent type incubator system, said intelligent type incubator system having a nurture/treatment equipment and being for manually varying a setpoint value of the nurture/treatment equipment according to a state of a corresponding life body, to nurture and/or treat the life body, wherein said nurture/treatment equipment contains an incubator for controlling an air environment containing temperature, humidity and an oxygen amount within a given space according to the setpoint value, an artificial respiratory machine for artificially breathing of a lungs-breath life body according to the setpoint value, and an injecting apparatus for injecting various kinds of injection agents onto the life body according to the setpoint value, said method comprising the steps of:

constructing a plural number of fuzzy inference rules on the basis of a statistical distribution of the setpoint value of the nurture/treatment equipment on state data of the life body, and forming the plural number of fuzzy inference rules as a neural network structure;

dividing the state data of the life body and its based setpoint value of the nurture/treatment equipment into a plurality of groups corresponding to the plural number of fuzzy inference rules, and establishing them, on the

basis of expert information on the nurture and/or treatment of the life body, and forming the respective established groups as the neural network structure;

separating individually various kinds of state data of the life body for a learning into groups based on the number of the inference rules;

deciding a coupling coefficient of the neural network through a repeated learning based on the neural network driven type fuzzy inference rules and the divided data, and also, deciding the coupling coefficient of the neural network of the respective groups through the repeated learning based on the neural network structure of the respective groups and the divided data;

deciding a membership value of the state data measured and inputted from a corresponding life body on the basis of the learned neural network driven-type fuzzy inference model;

deciding an estimation value of a corresponding setpoint value of the nurture/treatment equipment for the state data measured and inputted, on the basis of the learned neural network model of the respective group; and

calculating the corresponding setpoint value of the nurture/treatment equipment on the basis of the decided membership value and estimation value, and controlling an output of a corresponding nurture/treatment

equipment on the basis of the calculated setpoint value.

3. The method of claim 2, wherein said setpoint value of said incubator contains a setpoint value for temperature, humidity, oxygen partial pressure and a flowing amount of air supplied to the incubator inside, said setpoint value of said artificial respiratory machine contains a setpoint value for expiration/inspiration pressure, an oxygen content, the breathing number per unit time, the humidity and the temperature, and said setpoint value of said injecting apparatus contains a setpoint value of an injection amount.

4. The method of claim 2 or 3, wherein said state data of the life body contains an electrocardiogram (ECG) having irregular pulse and the pulse number, the breathing number, an oxygen saturation degree, percutaneous oxygen partial pressure, percutaneous dioxide partial pressure, body temperature, weight and ages.

DRAWINGS

FIG 1

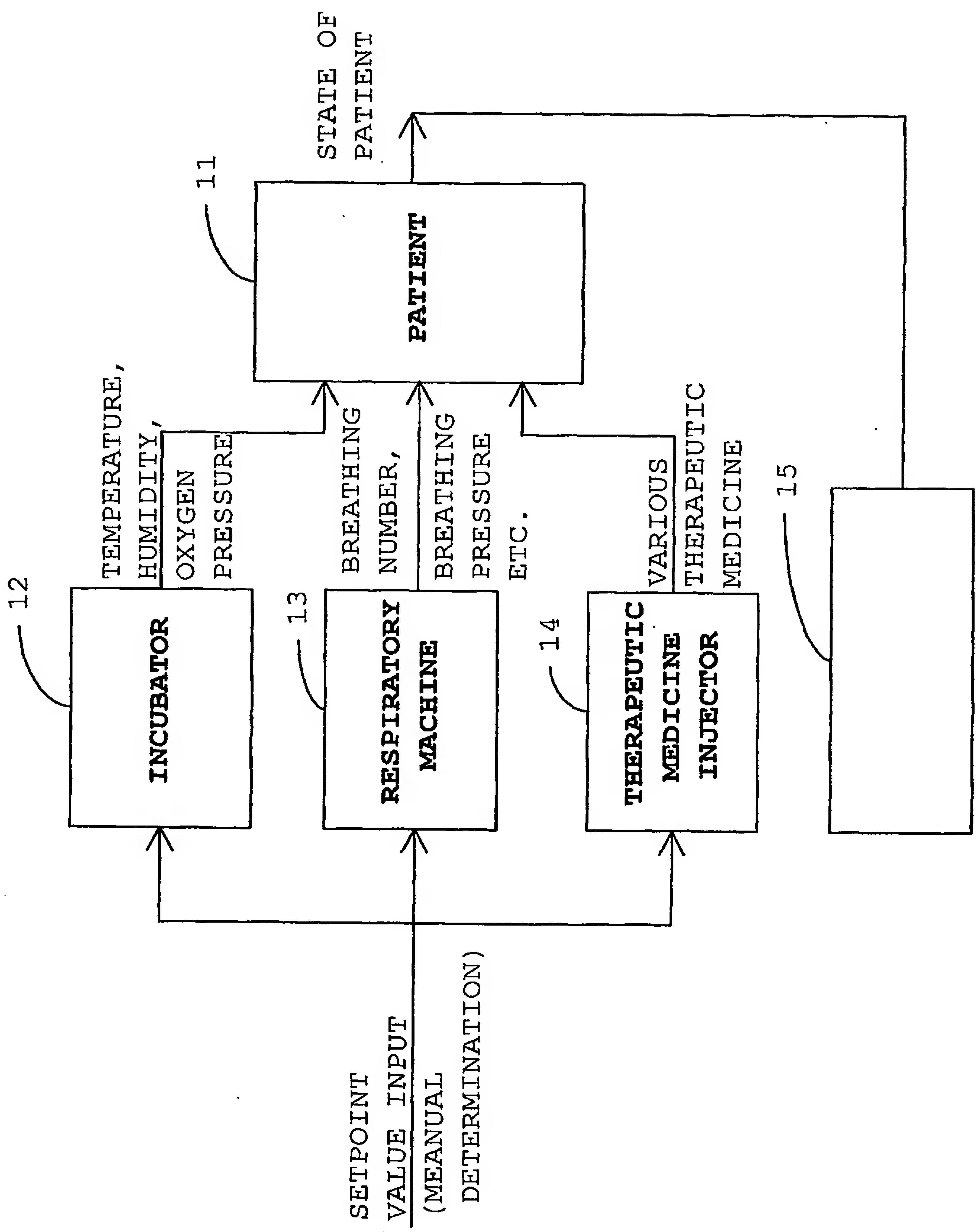


FIG 2

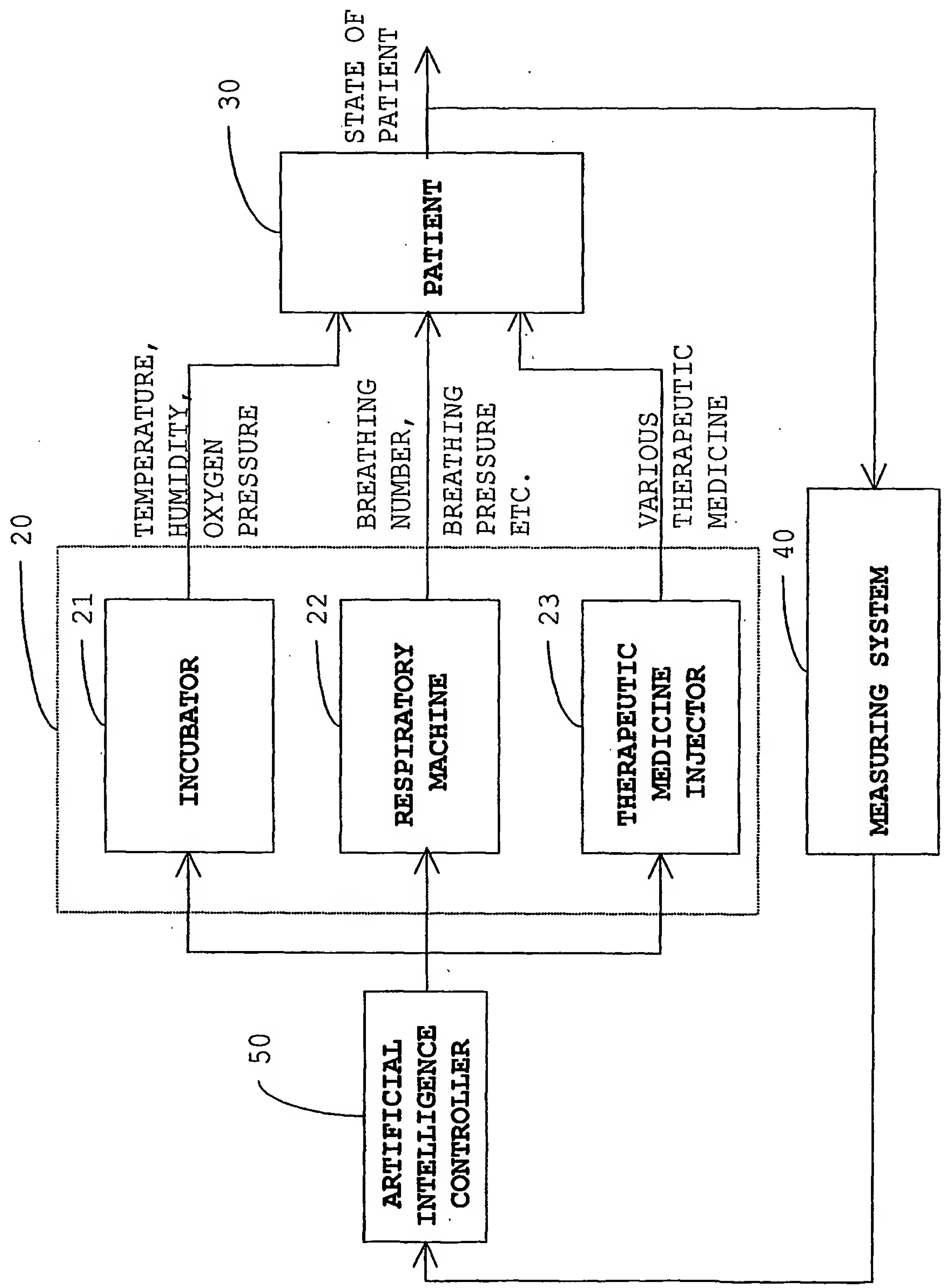
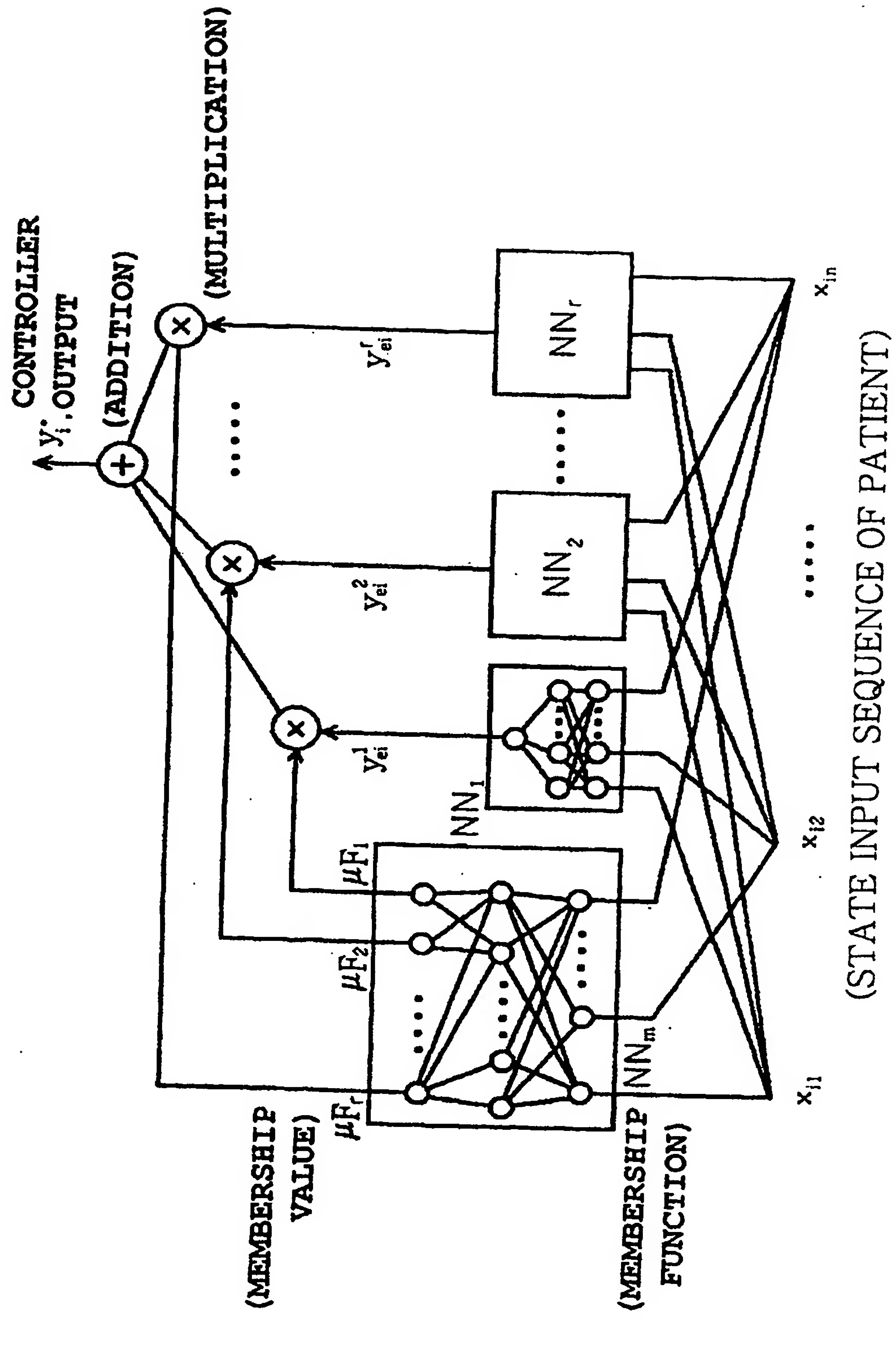

30
PATIENT
STATE OF PATIENT
TEMPERATURE, HUMIDITY, OXYGEN PRESSURE
BREATHING NUMBER, BREATHING PRESSURE ETC.
VARIOUS THERAPEUTIC MEDICINE
20
21
INCUBATOR
22
RESPIRATORY MACHINE
23
THERAPEUTIC MEDICINE INJECTOR
40
MEASURING SYSTEM
50
ARTIFICIAL INTELLIGENCE CONTROLLER

FIG 3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(MULTIPLICATION)
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y_{ei}^2
y_{ei}^1
NN_r
NN_2
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NN_m
μF_1
μF_2
μF_r
(MEMBERSHIP VALUE)
(MEMBERSHIP FUNCTION)
x_{i1}
x_{i2}
x_{in}
(STATE INPUT SEQUENCE OF PATIENT)

FIG 4

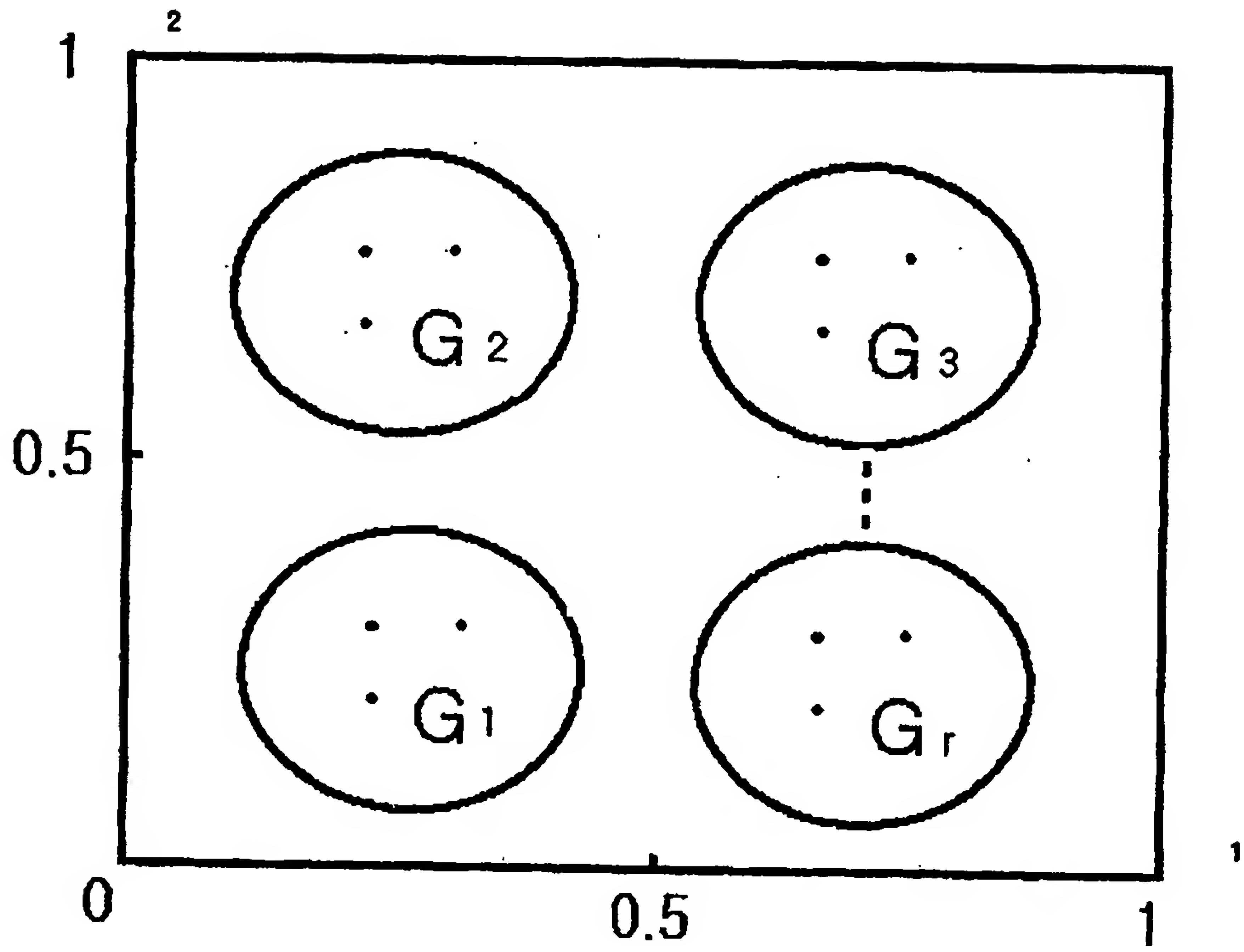
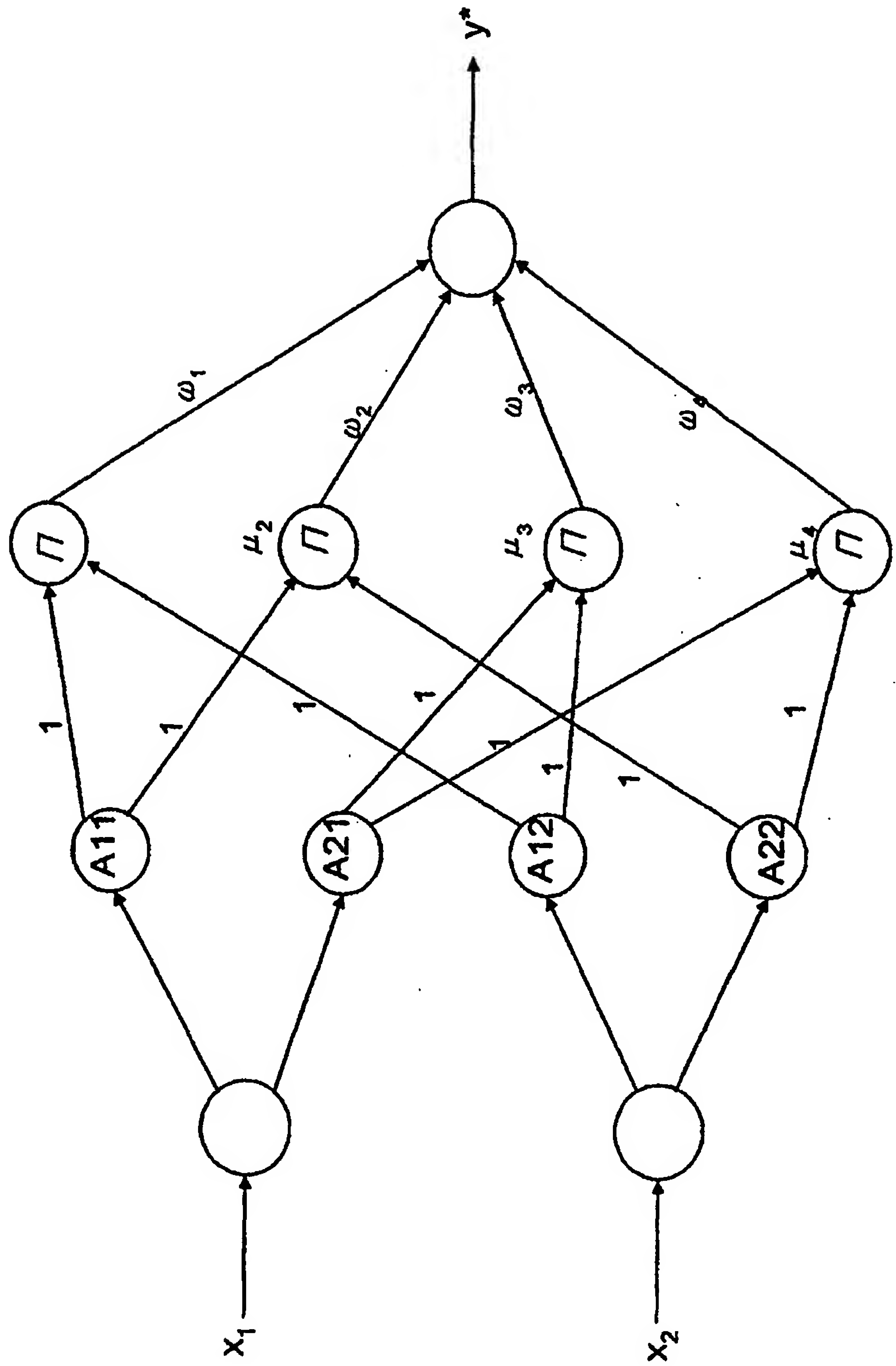


FIG 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/00767

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 A61G 11/00, A61B 5/08, G08B 23/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 A61G 11/00, A61B 5/08, G08B 23/00

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and applications for inventions since 1975
Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

NPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,316,542 A (DRAEGERWERK AG) 31. May, 1994 see claims	1
A	US 4,509,505 A (CALHENE) 9. Apr, 1985 see the whole document	1
A	US 5,446,934 A (FRAZIER RICHARD K) 5. Sep, 1995 see the whole document	1

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:
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"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 AUGUST 2001 (28.08.2001)	30 AUGUST 2001 (30.08.2001)

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, Dunsan-dong, Seo-gu, Daejeon Metropolitan City 302-701, Republic of Korea	JOO, Young Sik
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5995

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR01/00767

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